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Serial and cross-correlation in the Spanish Stock Market returns

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ABSTRACT

In this paper, we test if stock index prices follow random walks in the Spanish Stock Market by means of variance ratios. We find strong evidence of positive autocorrelation for both IGBM and IBEX35 daily returns until 1977, but not after that date. Although weekly and monthly index positive autocorrelations are not significant during the years 1972-2002, there is significant positive monthly cross-correlation between portfolios based on size. In particular, large stock portfolios seem to lead to the small stock ones.

Keywords: Market efficiency, random walk, variance ratio, cross-correlation.

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1 Introduction

It is well documented in the literature that stock indices exhibit positive autocorrelation (see, e.g., Fisher, 1966; Scholes and Willians, 1977; Dimson, 1979; Hawawini, 1980; and Lo and MacKinlay, 1988) while individual securities only show weakly positive or negative autocorrelation in short horizon returns (see, e.g., Fama, 1965; French and Roll, 1986; Lo and MacKinlay, 1988). For instance, Lo and MacKinlay (1988) find a weekly return first-order autocorrelation of approximately 30% for the CRSP equally-weighted index and for the period September 1962 to December 1985. They show that stock non-synchronous trading probabilities should be implausible high to explain completely the positive index autocorrelation. Thus, using heterocedasticity robust variance ratio tests, they reject that stock market prices follow random walks. Although, Boudoukh et al. (1994) argue that non-synchronous trading effect can be understated in the Lo and MacKinlay non-synchronous trading model, Kadlec and Patterson (1999) find, calibrating non-trading frequencies, that non-trading can only explain 85, 52 and 36% of daily autocorrelation on portfolios of small, random and large stocks respectively in the US Stock Market.

Conrad and Kaul (1988) try to explain index autocorrelation by autocorrelation in the underlying expected stock returns. However, Mech (1993) argue that if we assume that expected returns to be positive, it should not be possible to predict negative portfolio returns. By contrast, he proposes a transaction cost model which market makers, uninformed traders and informed investors are involved in. Mech (1993) concludes that transaction costs cause portfolio return autocorrelation. Stock prices do not always reflect all available information but investors cannot exploit this mispricing due to the transaction costs. Thus, market is not efficient but investors are not irrationals. Ahn et al. (2002), however, analyzing spot and future contracts, point toward microstructure-based instead of transaction cost explanations as the determinant of positive index autocorrelation.

Another well known phenomenum is that stock returns exhibit positive cross-correlation at different leads and lags. Lo and MacKinlay (1990) construct size portfolios and show that large size portfolios returns lead small size portfolio returns for a CRSP stock sample during the period July 1962 to December 1987. Apart from non-synchronous trading explanation, Badrinath et al. (1995) think that firm size is a proxy for information produced by investors. Because of set-up cost to information processing –referred by Merton (1987)–, institutional investors concentrate their attention in a small sample of stocks –usually the most liquid and largest– while other types of stocks are more likely to be hold by uninformed investors. Institutional investors trade based on the information they process, and uninformed investors know market information looking at institutional-favored stock prices but, logically, with a lag. Thus, there is a positive cross-correlation between institutional-favored stock returns and institutional-unfavored stock ones.

Chan (1993) points out another possible source of positive cross-correlation between securities: partial adjustment. Assuming that a market maker receives information only about his stock in each period of time, when he receives a favorable or unfavorable signal about his stock in period 1, he only *partially* will adjust the stock price. In period 2, he observes the other stock price changes; if they are in the same direction that first signal indicated, the market maker totally adjusts his stock price.

De Long et al. (1990) pay specific attention to the presence of noise traders in the stock markets. Noise traders can push prices far away from their fundamental values. Although, it has been thought that noise traders disappear from the market loosing the money against arbitrageur strategies, this could not happen given that the arbitrageurs are risk averse and their investment horizons are usually shorts. For example, if noise traders are bullish about a security, this one will be overvalued. An arbitrageur could sell the security short but he has to recognize that noise traders can become even more optimistic about the stock until he has to buy it back. Thus, there exists a different risk from the fundamental one: the unpredictability of noise trader opinion changes. There is probably mean reversion in stock prices at long-horizons but it could not be at short-horizons.

Herd behavior may also explain cross-correlation. Scharfstein and Stein (1990) suggest that professional managers *follow the herd*, i.e., they mimic the investment decisions of other managers instead of exploiting their substantial private information, because of reputation.

The aim of this paper is to provide empirical evidence of serially autocorrelation and cross-correlation between securities in the Spanish Stock Market. The paper is organized as follow: Section 2 describes the data; Section 3 describes variance ratios; Section 4 tests both index and individual stock autocorrelations by means of variance ratios; Section 5 studies cross-correlation between securities at different leads and lags; while Section 6 concludes.

2 Data

We have available IGBM (Indice General de la Bolsa de Madrid) and IBEX35 computed daily quotation since January 4th 1966 and January 14th 1987 respectively to March 31st 2002, along with a sample of 145 stock monthly returns that quote or have been quoted in the Spanish Stock Market Interconnection System (SIBE) during the period February 14th 1986 and March 31st 2002. The IGBM is a value-weighted index by market capitalization which includes most of the SIBE securities, while the IBEX35 is a value-weighted index that contains the thirty five most traded stocks of the Spanish Stock Market. Every semester the effective trading volumes of all stocks are studied in order to adjust them and their weights that will form the IBEX35 index in the next semester. This index was created on December 31st 1989, although we have quotations calculated retrospectively since 1987. Until 2000, the IBEX35 stock weights were based in their market values but since 2000 they are based only in their free float capital.

3 Variance Ratio Tests

In this section, we briefly describe a survey of variance ratio tests, which have been used to test the efficient market hypothesis in its weak form.

3.1 I.I.D. Returns

Stock prices are said to follow a random walk if:

$$p_t = \mu + p_{t-1} + u_t , \tag{1}$$

where p_t is the stock log-price at time *t*, μ is a drift and u_t is i.i.d. (independent and identically distributed) normal with zero mean and standard deviation σ.[1] If first differences are considered, the null hypothesis is:

$$\text{H}_0\text{: } r_t = \mu + u_t , \tag{2}$$

where r_t is the one-period compounding return. If H_0 (2) holds, the one-period and the q-period compounding return variances should be respectively:

$$V[r_t] = \sigma^2 \text{ and } V[r_t(q)] = V[r_t + r_{t-1} + ... + r_{t-q+1}] = q\sigma^2 .$$

Thus, the q-period variance ratio is defined as:

$$VR(q) = \frac{V[r_t(q)]}{q \cdot V[r_t]}, \tag{3}$$

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[1] We take log-prices to avoid violating limited liability. Otherwise, the probability of a negative stock price would be positive under normality.

and it should be equal one under H_0 (2). Cochrane (1988) shows that the q-period variance ratio is a linear function of the (q-1) first autocorrelation coefficients, i.e.:

$$VR(q) = 1 + 2 \cdot \sum_{k=1}^{q-1} \left(1 - \frac{k}{q} \right) \cdot \rho_k \ . \tag{4}$$

In order to estimate the q-period variance ratio, let's suppose that our (Tq+1) size log-price sample is $\{p_0, p_1, ..., p_{Tq+1}\}$. Then, the finite-sample unbiased one-period and q-period variance estimators are:

$$\overline{\sigma}^2 = \frac{1}{Tq-1} \sum_{t=1}^{Tq} (r_t - \hat{\mu})^2 \ \text{ and } \ \overline{\sigma}_q^2 = \frac{1}{m} \sum_{t=q}^{Tq} (r_t(q) - q\hat{\mu})^2 \ ,$$

where:

$$\hat{\mu} = \frac{1}{Tq} \sum_{t=1}^{Tq} r_t = \frac{1}{Tq} \left(p_{Tq} - p_0 \right) \text{ and } m = q(Tq - q + 1)\left(1 - \frac{q}{Tq} \right).$$

Cochrane's formula is still valid asymptotically, substituting the true autocorrelation coefficients by their sample ones.

It can be shown that the finite sample unbiased variance ratio, $\overline{VR}(q) = \overline{\sigma}_q^2 / \overline{\sigma}^2$, follows under H_0 (2):

$$\overline{VR}(q) \xrightarrow[d]{} N\left(1, \sqrt{\frac{2(2q-1)(q-1)}{(3q)(Tq)}} \right) \text{ as } T \to \infty \ . \tag{5}$$

3.2 Uncorrelated returns

In the last subsection, we have made the assumption that log-price increments are i.i.d. However, this is a quite strong assumption given that volatility changes in different periods. Thus, the rejection of H_0 (2) could be due to non-i.i.d. increments rather than to the fact stock prices do not follow random walks.

In order to avoid this drawback, Lo and MacKinlay (1988) drive the heterocedasticity-consistent variance ratio distribution under H_0 (2) assuming that u_t are uncorrelated, and some other mild conditions. In this case:

$$Z_H(q) = \frac{\sqrt{Tq}\left(\overline{VR}(q)-1\right)}{\sqrt{\hat{\theta}(q)}} \xrightarrow[d]{} N(0,1) \text{ as } T \to \infty, \tag{6}$$

where:

$$\hat{\theta}(q) = 4\sum_{k=1}^{q-1}\left(1-\frac{k}{q}\right)^2 \cdot \hat{\delta}_k \text{ and } \hat{\delta}_k = \frac{Tq\sum_{t=k+1}^{Tq}(r_t-\hat{\mu})^2(r_{t-k}-\hat{\mu})^2}{\left[\sum_{t=1}^{Tq}(r_t-\hat{\mu})^2\right]^2}.$$

4 Empirical Evidence

In this section, we study the daily, weekly and monthly return autocorrelations in the Spanish Stock Market for the two indexes (IGBM, IBEX35) and for individual securities by means of variance ratio tests. We also provide the five first-order autocorrelation coefficients and the fifth and tenth-order Ljung-Box statistics. Recall that, assuming u_t i.i.d., and under H_0 (2):

$$\hat{\rho}_k \xrightarrow[d]{} N\left(0, \frac{1}{\sqrt{T}}\right) \text{ as } T \to \infty, \tag{7}$$

where T is the sample size. On the other hand, the Ljung-Box statistic:

$$Q_q = T(T+2)\sum_{k=1}^{q}\frac{\rho^2(k)}{T-k}, \tag{8}$$

follows asymptotically a chi-square with q degrees of freedom, if the above same assumptions are made.

If stock prices follow random walks, each q-period variance ratio should be equal to one. Following Chow and Denning (1993), we consider an overall test size, α%, and several pre-specified q-period variance ratio. The individual significance level for every pre-specified variance ratio will be $\alpha_i = 1 - (1-\alpha)^{1/m}$, where m is the number of pre-specified variance ratios. In this way, we control for the Type I error.

In this paper, we fix a number of 4 variance ratio for daily, weekly and monthly IGBM and IBEX35 returns. For daily returns, we select periods of two days (q=2); and one (q=5), two (q=10) and three (q=15) weeks. For weekly returns, the variance ratios correspond to approximately half (q=2), one (q=4), two (q=8) and four (q=16) months. For monthly returns, we display variance ratios for two (q=2), four (q=4), six (q=6) months and a year (q=12). For an overall significance level of $\alpha = 5\%$ and for $m = 4$, the individual significance level is $\alpha_i = 0.0064$ and its standard normal value is 2.491.

The test are performed for the whole samples as well as for five years subsamples. Every subsample begins and ends at March 31st, except the first ones which begin at January 4th 1966 for IGBM and at January 14th 1987 for IBEX35 respectively. They are longer than the rest of subsamples.

(Insert Table 1 and Table 2 about here)

Table 1 provides first-order autocorrelation coefficients and the fifth and tenth-order Ljung-Box statistics for IGBM daily autocorrelations. The first four autocorrelation coefficients are positive and significant during the period January 4th 1966 – March 31st 2002. We strongly reject the null hypothesis that the first five and ten autocorrelation coefficients are equal to zero using the Ljung-Box statistic. Regarding the subsamples, note that the first-order autocorrelation coefficient decreases since 1987 although remains being statistically different from zero. In the same way, the Ljung-Box statistics fall from 314.70 and 346.43 in 66-72 to 11.13 and 19.86 in 97-02. Table 2 shows the two, five, ten and fifteen-period variance ratios and their corresponding heterocedasticity-consistent normalized standard values for IGBM daily returns. We reject that IGBM daily prices follow random walks between January 4th 1966 – March 31st 2002. However, the Z_H values decrease along the subsamples until they become non-significant for the last subperiod 97-02. Therefore, we do not have empirical evidence to reject the random walk hypothesis for IGBM daily prices during the last five years (97-02).

(Insert Table 3 and Table 4 about here)

In Table 3, we see that the IBEX35 daily return first-order autocorrelation coefficients is higher than two times their standard errors both for the sample January 14th 1987 – March 31st 2002 and for the five-year subsamples. The first order autocorrelation coefficient and the Ljung-Box statistics decrease since 87-92 to 97-02. There is no empirical evidence to reject that the five first autocorrelation coefficients are jointly null but there is for the ten first ones which suggests that higher autocorrelation coefficients are not close to zero. Looking at Table 4, we observe similar results as in Table 2. Variance ratios are significant for the whole sample. However, we cannot reject IBEX35 daily prices follow random walks during the last five years (97-02). The majority of variance ratios are greater than one, which means positive autocorrelation in returns.

(Insert Table 5 and Table 6 about here)

Focussing on IGBM and IBEX35 weekly returns, we see in Table 5 that although there is enough evidence to reject the absence of serial correlation in the entire IGBM sample and the first five subsamples, we cannot reject it neither in 92-97 nor in 97-02. Furthermore, assuming uncorrelated errors, Table 6 shows that IGBM weekly prices follow random walks except for the subperiod 66-72.

(Insert Table 7 and Table 8 about here)

Random walk hypothesis for IBEX35 weekly prices is never rejected neither under i.i.d. errors –see Table 7– nor under uncorrelated ones –see Table 8–. The significance of Ljung-Box statistics for 87-02 IBEX35 weekly returns could be due to changes in volatility prices along that period.

(Insert Table 9, Table 10, Table 11 and Table 12 about here)

We never reject that monthly IGBM and IBEX35 prices follow random walks, as Table 9 to Table 12 show, except for first-order autocorrelation and tenth Ljung-Box statistics in 66-02 IGBM values (probably caused by heterocedasticity). Several monthly variance ratios are lower than one, indicating evidence of negative autocorrelation, specially during the last five years (97-02).

In short, the empirical evidence in the Spanish Stock Market is similar to other Stock Markets in the world: The shorter return periods, the higher positive serial correlation in index returns. On the other hand, the above tables indicate that IGBM variance ratios are always higher than IBEX35 ones –except for monthly 97-02 period–. Taking into account that IGBM contains most of the Spanish Stock Market Interconnection System (SIBE, Sistema de Interconexión Bursátil Español) securities while IBEX35 only includes the most traded 35 stocks –which are highly correlated with the largest 35 ones–, it suggests that small stock portfolios should be stronger autocorrelated than large stock ones.

Finally, Tables 13 and 14 show the average daily return autocorrelation coefficients and several variance ratios of 145 SIBE individual securities for the period February 14th 1986 to March 31st 2002. Standard deviations are also provided to indicate the stock autocorrelation and variance ratio variability. However, standard deviations are not valid to test if autocorrelation coefficients and variance ratio means are null given that these cannot be considered independent between stocks. We conclude that individual securities in the Spanish Stock Market are weakly positive autocorrelated.[2]

If individual securities are weekly positive autocorrelated while stock indexes (IGBM, IBEX35) are stronger positive autocorrelated, there should be cross-correlation between stock returns in the Spanish Stock Market. This issue is examined in the next section.

5 Cross-correlation in the Spanish Stock Market

Lo and MacKinlay (1990) discover that cross-correlation across stocks are responsible for index positive autocorrelation for CRSP securities during the period July 6th 1962 - December 31st 1987. In the last decade, several explanations of this fact –involving non-synchronous trading, information processing, the way market-makers trade, noise traders, herd behavior, etc.– have been given.

In this section, we analyze cross-correlation across securities and across time for five portfolios based on size during the period April 1988 to March 2000. At every March 31st, since 1988 to 1999, we form and update five portfolios –with approximately the same number of stocks– based on their market values, and calculate equally-weighted monthly returns during the next twelve months until the next March 31st, when we resort the stocks based again on their market values and update the size portfolios. The firm size or market value is measured as the number of outstanding stocks times the stock close price in the last March trading day. The k-lag cross-correlation coefficient between a portfolio *i* and a portfolio *j* is defined as:

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[2] Lo and MacKinlay (1988), among others, document weekly negative autocorrelations for CRSP individual stocks.

$$\rho\left(R_{it-k}, R_{jt}\right) = \frac{\operatorname{cov}\left(R_{it-k}, R_{jt}\right)}{\sqrt{V\left(R_{it-k}\right)}\sqrt{V\left(R_{jt}\right)}} = \frac{T\sum_{t=k+1}^{T}\left(R_{it-k} - \overline{R}_i\right)\left(R_{jt} - \overline{R}_j\right)}{\left(T-k\right)\sqrt{\sum_{t=k}^{T}\left(R_{it-k} - \overline{R}_i\right)^2}\sqrt{\sum_{t=k}^{T}\left(R_{jt} - \overline{R}_j\right)^2}}, \quad (9)$$

where R_{lt} is the l portfolio simple return at time t and $\overline{R}_l$ is the l portfolio average return.

(Insert Table 15 about here)

Table 15 shows monthly return cross-correlations from zero to three-lags among five size portfolios. For contemporaneous correlations, note that the greater disparity between portfolio market values the lower correlation between portfolios. Regarding one lag correlations, the smallest size portfolio monthly returns can be explain by Portfolios 3, 4 and 5 one lag monthly returns; Portfolio 4 can be done by Portfolios 1, 2, 3 and 4; Portfolio 3 by Portfolios 1, 2, 3 and 4; Portfolio 2 by Portfolios 2, 3 and 4; and Portfolio 1 by no one. Thus, each size portfolio monthly return can be explained by larger size portfolio monthly ones –except Portfolio 2–. This means that bigger stocks lead smaller ones. This support Badrinath et al. (1995) institutional-favored stocks and institutional-unfavored ones story. Most of IBEX35 stocks are contained in Portfolio 1 and Portfolio 2 and are followed closely by institutional analysts while non IBEX35 securities generate less amount of information. Therefore, part of IBEX35 stock information which concerns to the market as a whole, is transmitted to small stock prices with a lag. It is quite difficult that only non-trading can cause the cross-correlation between size portfolios, specially when we compute cross-correlations in monthly periods. Higher one lag cross-correlation between portfolios are not significant.

6 Concluding Remarks

In the NYSE and other stock markets, it is well known that index returns exhibit significant positive autocorrelation –specially, in daily and weekly periods– while individual securities returns are usually weakly positive or negative autocorrelated. Lo and MacKinlay (1990) show that the different performance between indexes and stocks is caused, among others, by positive correlation across stocks and across time. Several causes have been suggested to explain this: non-synchronous trading, information processing, noise traders, transaction costs, herd behavior, etc.

In this paper we test if index and stock prices follow random walks in Spain by means of variance ratios. We find positive strong autocorrelation for both IGBM and IBEX35 index daily returns until 1997 but we cannot reject the random walk hypothesis for the period March 31st 1997 – March 31st 2002. Regarding weekly returns, we have only empirical evidence of IGBM positive autocorrelation for the period January 4th 1966 – March 31st 1972. The positive index autocorrelation monthly returns are not significant at 5% level in any period. On the other hand, Spanish Stock Market security daily returns show weakly positive autocorrelation.

Even though index monthly return positive autocorrelations are low, there is strong evidence of monthly return cross-correlation at one lag (a month) between portfolios based on size. In particular, large stock portfolios lead to the small stock ones which seem to support –apart from non-trading– the Badrinath et al. (1995) institutional-favored and institutional-unfavored security explanation.

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Table 1

Autocorrelations in IGBM daily returns

	66–02	66–72	72–77	77–82	82–87	87–92	92–97	97–02
$\hat{\rho}_1$	**0.245**	**0.475**	**0.451**	**0.485**	**0.463**	**0.218**	**0.146**	**0.060**
$\hat{\rho}_2$	**0.039**	**0.167**	**0.117**	**0.154**	**0.121**	0.048	0.024	–0.070
$\hat{\rho}_3$	**0.024**	0.051	**0.081**	0.040	0.053	0.040	–0.019	–0.010
$\hat{\rho}_4$	**0.030**	0.030	**0.087**	–0.008	0.053	0.039	0.008	0.014
$\hat{\rho}_5$	0.000	0.009	0.006	–0.040	0.012	–0.015	–0.013	0.010
Q_5	**507.29**	**314.70**	**223.08**	**257.91**	**264.43**	**66.03**	**27.87**	**11.13**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.049)
Q_{10}	**547.11**	**346.43**	**230.78**	**261.90**	**267.31**	**93.94**	**30.49**	**19.86**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.031)

Five first-order autocorrelation coefficients, and fifth and tenth-order Ljung-Box statistics for IGBM daily returns. The sample period (66-02) begins at January 4th 1966 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 4th 1966. Autocorrelation coefficients higher that two times their standard errors and significant Ljung-Box statistics at 5% level are in bold.

Table 2

Variance Ratios for IGBM daily returns

VR	66–02	66–72	72–77	77–82	82–87	87–92	92–97	97–02
2	**1.245**	**1.475**	**1.451**	**1.485**	**1.463**	**1.218**	**1.146**	1.060
	(12.546)	(10.365)	(10.212)	(9.571)	(9.941)	(3.572)	(4.473)	(1.677)
5	**1.470**	**2.013**	**1.962**	**1.990**	**1.950**	**1.454**	**1.250**	1.010
	(11.060)	(11.135)	(10.760)	(9.401)	(10.037)	(3.348)	(3.429)	(0.123)
10	**1.613**	**2.366**	**2.300**	**2.160**	**2.186**	**1.664**	1.256	1.007
	(9.654)	(10.402)	(9.499)	(7.603)	(8.363)	(3.374)	(2.300)	(0.056)
15	**1.732**	**2.656**	**2.468**	**2.244**	**2.338**	**1.828**	1.300	1.052
	(9.370)	(10.267)	(8.637)	(6.756)	(7.602)	(3.515)	(2.158)	(0.342)

Two, five, ten and fifteen-order variance ratios for IGBM daily returns. The sample period (66-02) begins at January 4th 1966 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 4th 1966. Heterocedasticity-consistent standard normal values, $Z_H(q)$, are given in parenthesis. Significant variance ratios at 5% overall level are in bold.

Table 3

Autocorrelations in IBEX35 daily returns

	87–02	87–92	92–97	97–02
$\hat{\rho}_1$	**0.111**	**0.191**	**0.128**	**0.056**
$\hat{\rho}_2$	–0.016	**0.057**	0.017	–0.073
$\hat{\rho}_3$	–0.001	0.028	–0.015	–0.011
$\hat{\rho}_4$	0.016	0.047	0.006	0.003
$\hat{\rho}_5$	–0.008	–0.038	–0.009	0.012
Q_5	**49.16** (0.000)	**57.08** (0.000)	**21.11** (0.001)	10.97 (0.052)
Q_{10}	**66.12** (0.000)	**71.30** (0.000)	**26.64** (0.003)	21.01 (0.021)

Five first-order autocorrelation coefficients, and fifth and tenth-order Ljung-Box statistics for IBEX35 daily returns. The sample period (87-02) begins at January 14th 1987 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 14th 1987. Autocorrelation coefficients higher that two times their standard errors and significant Ljung-Box statistics at 5% level are in bold.

Table 4

Variance Ratios for IBEX35 daily returns

VR	87–02	87–92	92–97	97–02
2	**1.111** (4.681)	**1.191** (4.052)	**1.128** (3.835)	1.056 (1.554)
5	**1.164** (3.056)	**1.415** (3.666)	**1.222** (2.684)	0.994 (–0.071)
10	1.200 (2.416)	**1.566** (3.253)	1.215 (1.926)	0.977 (–0.191)
15	**1.258** (2.499)	**1.669** (3.246)	1.247 (1.780)	1.008 (0.050)

Two, five, ten and fifteen-order variance ratios for IBEX35 daily returns. The sample period (87-02) begins at January 14th 1987 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 14th 1987. Heterocedasticity-consistent standard normal values, $Z_H(q)$, are given in parenthesis. Significant variance ratios at 5% overall level are in bold.

Table 5

Autocorrelations in IGBM weekly returns

	66–02	66–72	72–77	77–82	82–87	87–92	92–97	97–02
$\hat{\rho}_1$	**0.132**	**0.203**	**0.184**	**0.177**	**0.136**	**0.127**	0.059	0.079
$\hat{\rho}_2$	**0.077**	**0.128**	0.094	–0.002	0.045	0.114	0.034	0.074
$\hat{\rho}_3$	**0.083**	0.092	–0.016	0.059	0.099	0.114	**0.127**	0.042
$\hat{\rho}_4$	0.008	**0.124**	–0.045	–0.026	0.020	–0.034	–0.016	0.040
$\hat{\rho}_5$	0.028	0.022	–0.036	0.021	–0.008	0.124	–0.017	–0.012
Q_5	**58.661**	**26.897**	**12.095**	**9.530**	8.083	**15.528**	5.669	4.007
	(0.000)	(0.000)	(0.034)	(0.000)	(0.152)	(0.008)	(0.340)	(0.548)
Q_{10}	**66.608**	**34.025**	18.187	**10.253**	13.658	**26.355**	8.269	12.671
	(0.000)	(0.000)	(0.052)	(0.000)	(0.189)	(0.003)	(0.603)	(0.243)

Five first-order autocorrelation coefficients, and fifth and tenth-order Ljung-Box statistics for IGBM weekly returns. The sample period (66-02) begins at January 4th 1966 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 4th 1966. Autocorrelation coefficients higher that two times their standard errors and significant Ljung-Box statistics at 5% level are in bold.

Table 6

Variance Ratios for IGBM weekly returns

VR	66–02	66–72	72–77	77–82	82–87	87–92	92–97	97–02
2	**1.132**	**1.203**	1.184	1.177	1.136	1.127	1.059	1.079
	(3.455)	(2.886)	(2.243)	(2.469)	(1.690)	(0.974)	(0.728)	(1.164)
4	**1.317**	**1.479**	1.362	1.293	1.299	1.362	1.186	1.214
	(4.603)	(3.474)	(2.445)	(2.192)	(1.940)	(1.659)	(1.302)	(1.529)
8	**1.488**	**1.771**	1.316	1.383	1.514	1.594	1.272	1.329
	(4.774)	(3.630)	(1.438)	(1.839)	(2.177)	(1.944)	(1.256)	(1.491)
16	**1.507**	**1.750**	1.226	1.506	1.578	1.341	1.486	1.213
	(3.514)	(2.544)	(0.734)	(1.657)	(1.693)	(0.826)	(1.562)	(0.665)

Two, four, eight and sixteen-order variance ratios for IGBM weekly returns. The sample period (66-02) begins at January 4th 1966 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 4th 1966. Heterocedasticity-consistent standard normal values, $Z_H(q)$, are given in parenthesis. Significant variance ratios at 5% overall level are in bold.

Table 7

Autocorrelations in IBEX35 weekly returns

	87–02	87–92	92–97	97–02
$\hat{\rho}_1$	0.070	0.097	0.054	0.056
$\hat{\rho}_2$	0.042	0.038	0.010	0.056
$\hat{\rho}_3$	**0.088**	0.089	0.109	0.078
$\hat{\rho}_4$	–0.008	–0.002	–0.025	0.000
$\hat{\rho}_5$	0.027	0.098	–0.016	–0.016
Q_5	**12.102**	7.804	4.171	3.328
	(0.033)	(0.167)	(0.525)	(0.650)
Q_{10}	**28.010**	16.352	7.951	14.091
	(0.002)	(0.090)	(0.634)	(0.169)

Five first-order autocorrelation coefficients, and fifth and tenth-order Ljung-Box statistics for IBEX35 weekly returns. The sample period (87-02) begins at January 14th 1987 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 14th 1987. Autocorrelation coefficients higher that two times their standard errors and significant Ljung-Box statistics at 5% level are in bold.

Table 8

Variance Ratios for IBEX35 weekly returns

VR	87–02	87–92	92–97	97–02
2	1.070	1.097	1.054	1.056
	(1.193)	(0.746)	(0.679)	(0.805)
4	1.191	1.228	1.146	1.179
	(1.834)	(1.058)	(1.035)	(1.249)
8	1.297	1.392	1.197	1.262
	(1.945)	(1.313)	(0.917)	(1.158)
16	1.171	1.107	1.386	1.122
	(0.797)	(0.264)	(1.233)	(0.372)

Two, four, eight and sixteen-order variance ratios for IBEX35 weekly returns. The sample period (87-02) begins at January 14th 1987 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 14th 1987. Heterocedasticity-consistent standard normal values, $Z_H(q)$, are given in parenthesis. Significant variance ratios at 5% overall level are in bold.

Table 9

Autocorrelations in IGBM monthly returns

	66–02	66–72	72–77	77–82	82–87	87–92	92–97	97–02
$\hat{\rho}_1$	**0.133**	0.176	–0.083	0.091	**0.313**	0.160	0.100	–0.100
$\hat{\rho}_2$	–0.007	–0.072	–0.099	0.178	–0.064	–0.180	0.089	0.010
$\hat{\rho}_3$	–0.019	0.117	0.152	–0.028	–0.030	**–0.269**	0.156	–0.095
$\hat{\rho}_4$	0.017	0.032	–0.160	–0.044	0.152	–0.075	–0.062	0.023
$\hat{\rho}_5$	0.028	0.081	0.079	0.195	0.141	–0.111	–0.104	–0.195
Q_5	8.34	4.54	4.61	5.24	9.24	9.49	3.04	3.16
	(0.138)	(0.474)	(0.466)	(0.388)	(0.100)	(0.091)	(0.694)	(0.676)
Q_{10}	**22.50**	12.03	10.92	6.85	14.74	11.30	13.78	6.89
	(0.013)	(0.283)	(0.364)	(0.740)	(0.142)	(0.335)	(0.183)	(0.736)

Five first-order autocorrelation coefficients, and fifth and tenth-order Ljung-Box statistics for IGBM monthly returns. The sample period (66-02) begins at January 4th 1966 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 4th 1966. Autocorrelation coefficients higher that two times their standard errors and significant Ljung-Box statistics at 5% level are in bold.

Table 10

Variance Ratios for IGBM monthly returns

VR	66–02	66–72	72–77	77–82	82–87	87–92	92–97	97–02
2	1.133	1.176	0.917	1.091	1.313	1.160	1.100	0.900
	(2.319)	(1.216)	(–0.792)	(0.947)	(1.951)	(1.153)	(0.666)	(–0.793)
4	1.183	1.251	0.853	1.301	1.391	0.926	1.317	0.813
	(1.730)	(1.041)	(–0.671)	(1.369)	(1.333)	(–0.291)	(1.205)	(–0.802)
6	1.214	1.363	0.801	1.397	1.555	0.671	1.365	0.702
	(1.540)	(1.216)	(–0,670)	(1.328)	(1.490)	(–0.953)	(1.088)	(–0.966)
12	1.471	1.779	0.936	1.498	1.602	0.364	1.398	0.636
	(2.267)	(1.790)	(–0.140)	(1.111)	(1.141)	(–0.274)	(0.824)	(–0.775)

Two, four, six and twelve-order variance ratios for IGBM monthly returns. The sample period (66-02) begins at January 4th 1966 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 4th 1966. Heterocedasticity-consistent standard normal values, $Z_H(q)$, are given in parenthesis. Significant variance ratios at 5% overall level are in bold.

Table 11

Autocorrelations in IBEX35 monthly returns

	87–02	87–92	92–97	97–02
$\hat{\rho}_1$	0.025	0.079	–0.002	–0.042
$\hat{\rho}_2$	–0.042	–0.163	0.085	0.000
$\hat{\rho}_3$	–0.115	–0.309	0.133	–0.071
$\hat{\rho}_4$	–0.026	–0.099	–0.081	0.043
$\hat{\rho}_5$	–0.105	–0.047	–0.115	–0.198
Q_5	5.14 (0.399)	9.54 (0.089)	2.90 (0.715)	3.19 (0.671)
Q_{10}	9.80 (0.458)	11.86 (0.294)	13.92 (0.177)	6.97 (0.728)

Five first-order autocorrelation coefficients, and fifth and tenth-order Ljung-Box statistics for IBEX35 monthly returns. The sample period (87-02) begins at January 14th 1987 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 14th 1987. Autocorrelation coefficients higher that two times their standard errors and significant Ljung-Box statistics at 5% level are in bold.

Table 12

Variance Ratios for IBEX35 monthly returns

VR	87–02	87–92	92–97	97–02
2	1.025 (0.333)	1.079 (0.650)	0.998 (–0.014)	0.958 (–0.328)
4	0.938 (–0.441)	0.801 (–0.868)	1.149 (0.574)	0.902 (–0.416)
6	0.818 (–0.946)	0.524 (–1.461)	1.151 (0.455)	0.822 (–0.574)
12	0.811 (–0.647)	0.338 (–1.338)	1.150 (0.313)	0.821 (–0.383)

Two, five, ten and fifteen-order variance ratios for IBEX35 monthly returns. The sample period (87-02) begins at January 14th 1987 and ends at March 31st 2002. Every subsample period begins and ends at March 31st except the first one, which begins at January 14th 1987. Heterocedasticity-consistent standard normal values, $Z_H(q)$, are given in parenthesis. Significant variance ratios at 5% overall level are in bold.

Table 13

Autocorrelations in individual securities daily returns

	$\hat{\rho}_1$	$\hat{\rho}_2$	$\hat{\rho}_3$	$\hat{\rho}_4$	$\hat{\rho}_5$
Mean	0.0265	–0.002	0.0209	0.0275	0.0336
S.D.	(0.1048)	(0.0467)	(0.0689)	(0.0373)	(0.0394)

Five first-order autocorrelation average coefficients and their corresponding standard deviations for 145 SIBE individual security daily returns. The sample period begins at February 14th 1986 and ends at March 31st 2002.

Table 14

Variance Ratios for individual securities daily returns

VR	2	5	10	15
Mean	1.026	1.020	1.010	1.019
S.D.	(0.105)	(0.191)	(0.245)	(0.274)

Two, five, ten and fifteen-order average variance ratios for 145 SIBE individual security daily returns. The sample period begins at February 14th 1986 and ends at March 31st 2002.

Table 15

Cross-correlation between size portfolio monthly returns

0 lags

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}
R_{1t}	**1**	**0.870**	**0.787**	**0.758**	**0.687**
R_{2t}	**0.870**	**1**	**0.893**	**0.838**	**0.769**
R_{3t}	**0.787**	**0.893**	**1**	**0.902**	**0.797**
R_{4t}	**0.758**	**0.838**	**0.902**	**1**	**0.874**
R_{5t}	**0.687**	**0.769**	**0.797**	**0.874**	**1**

1 lag

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}
R_{1t-1}	0.035	0.145	**0.197**	**0.210**	**0.166**
R_{2t-1}	0.102	**0.229**	**0.262**	**0.273**	**0.234**
R_{3t-1}	0.068	**0.228**	**0.244**	**0.265**	**0.240**
R_{4t-1}	0.020	**0.173**	**0.212**	**0.214**	**0.198**
R_{5t-1}	0.016	0.098	0.145	0.145	0.106

2 lags

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}
R_{1t-2}	–0.021	–0.050	–0.010	–0.011	–0.016
R_{2t-2}	–0.004	–0.014	0	0.033	0.014
R_{3t-2}	–0.011	–0.003	0.016	0.027	0.010
R_{4t-2}	–0.005	–0.006	–0.005	0.024	0.009
R_{5t-2}	0.024	0.003	0.145	0.145	0.106

3 lags

	R_{1t}	R_{2t}	R_{3t}	R_{4t}	R_{5t}
R_{1t-3}	0.021	0.037	0.076	0.101	0.047
R_{2t-3}	0.011	0.056	0.080	0.109	0.091
R_{3t-3}	0.011	0.078	0.097	0.116	0.111
R_{4t-3}	–0.009	0.060	0.073	0.073	0.048
R_{5t-3}	–0.031	0.045	0.093	0.080	0.078

Monthly equally-weighted return cross-correlations at zero to three lags between five portfolios based on size during the period April 1988 to March 2000. The portfolios are created on March 31st and their composition remain constant until the next March 31st, date which are updated in. The five portfolios contains approximately the same number of stocks. The correlation coefficients higher than two times the correlation standard error, 0.083, are in bold.